Process to code and decode digital data stored or transmitted according to the prioritized pixel transmission method.

This invention comprises a process to code and decode digital data transmitted or stored via the prioritized pixel transmission method according to the preamble of patent claim 1.

The creation of informational content, such as pictures, videos, audio data and documents, is very complex. In the transmission and storage of such informational content, in many applications it is sensible and necessary to code the information in order to protect it against unauthorized access. To this end, there are a series of coding methods and applications that meet this need.

In the process, coding of information can be done at various levels.
- directly in an application, for example using code word protection in personal computers or for access to a program
- independent of an application, for example by means of the well-known PGP encoding method in the case of E-mail applications
- during the transmission of the information, for example the transmission of information over the Internet, using IPSec (Internet Protocol Security).

Prior art coding methods do not have the ability to code the information flexibly and scalably. This means that there isn't any way to flexibly adjust coding processes according to the information content and the specific application. Such flexibility can, however be sensible if it is desired to offer video on demand, for example, wherein different fees are to be assessed for different video qualities, for example in as a function of the screen resolution.

The object of the invention is to provide a method for coding and decoding of digital data transmitted or stored according to the prioritized pixel transmission method, thereby making it possible to code the information flexibly and scalably.

This object is met according to the invention by the features of patent claim 1.

The bases for the process according to the invention include the methods of compression and decompression of picture and video data using prioritized pixel transmission as described in the German patent applications DE 101 13 880.6 (corresponding to PCT/DE02/00987) and DE 101 52 612.1 (corresponding to PCT/DE02/00995). In these methods, the digital data processed, for example image or video data, consist of an array of individual image points (pixels), wherein each pixel contains a pixel value, which can change over time, that provides information on the color or brightness of the pixel. According to the invention, each pixel or pixel group is assigned a priority, and the pixels are filed in a priority array according to their prioritization. At any given time, this array contains the pixel values sorted according to this prioritization. These pixels and the pixel values used for the calculation of their prioritization are transmitted or stored according to the prioritization. A pixel receives a high priority if the difference from its adjacent

pixel is very large. During reconstruction, the current pixel values are shown on the display. The pixels that have still not been transmitted are calculated from the pixels already transmitted.

The disclosure of application DE 101 13 880.6 and DE 101 52 612.1 should be included in their entirety in the disclosure of this invention.

According to this invention, the transmission and storage of the prioritized pixel groups is done in the form of data packets, wherein the data packets can contain not just image data in the form of image points (pixels), but can contain any type of digital data that can be stored in an array. The data packet consists of a data value that described the position of the pixel group in the array and also contains the values of the individual pixels of the pixel group. By coding the positional value of the pixel group and/or the pixel values of the pixel group, it becomes possible to protect the data contents against unauthorized access. Depending on the keys used and on which portions of the information content are coded, for example positional values and/or pixel group values, a wide variety of coding needs can be met. The data packets are transmitted and/or stored in descending order according to importance. Thus, according to the invention it is possible to code and decode the pixel groups according to their importance, at least for static, temporally unchanging n-dimensional arrays.

The advantage of the invention compared to the current state of the art is in the scalable manipulation of the coding method. In contrast to usual methods, separately coding the positional values and/or pixel group values offers the advantage that this becomes the only method necessary to incorporated in to the respective applications and devices when different requirements arise. Once this method is implemented, a wide variety of requirements can utilize the same method. This reduces the number of implementations, which among other things saves memory space, which is of limited availability, particularly for mobile end users. The reduction of the number of implementations is due to the ability to code audio, image and video data with the same method.

Advantageous embodiments and further developments of the invention are indicated in the subordinate claims.

Short description of the drawings:

Figure 1   A representation of an image array made up of 20 x 21 pixels;

Figure 2   A representation of various forms of pixel groups;

Figure 3:   A newly generated image array with pixel groups inserted in the corners of the image;

Figure 4:   Filling in the surfaces between the pixel groups already inserted;

Figure 5:   Inserting more pixel groups and filling in the intermediate surfaces.

A few exemplary embodiments of the invention are explained below.

It is assumed that the information content exists as a 2-dimensional image file (image array). Each image point (pixel) of the image array is represented by a 32 Bit value (pixel value), for example. The 32 Bits are divided into 4 values (transparent, red, green, blue), each with 8 Bits. The image points of the image array are enumerated, with the position of each pixel being given a whole number value. Pixel groups are formed consisting of a reference pixel that indicates the position of the pixel group within the array, and other pixels that surround the reference pixel. Each pixel group is assigned a priority depending on its "image importance", with the pixel groups with the highest priority being stored or transmitted first.

The pixel groups can now be transmitted or stored at different coding levels according to the invention.

No coding:
Free access to all information content, i.e. the pixel groups are transmitted in un-coded form.

Use of a simple key:
A single key is used to code and decode, i.e. a symmetric coding process is used. In this method for example, the positional values of the reference pixels of a pixel group can be coded so that without the right key, it is impossible to place the pixel groups in the right position in the image array. The key can be transmitted via a second transmission path, for example via Email or regular mail. No other infrastructure is necessary. A symmetric coding method is faster than an asymmetric method such as PGP.

Use of an asymmetric coding method: a private and public key are used to code and decode the information content, respectively. The coding is complex compared to symmetric methods, and is limited to only point-to-point relationships. However, it is not necessary to transmit the key via a second transmission path.

Use of a multiple key:
A multiple is made up of a combination of individual keys. The keys can be dependent on information content, on time, original source, on transmission medium or on other features.

This allows the playback of information content to be limited arbitrarily as needed, allowing the information to be displayed according to the situation. Here are a few examples:

- Temporal components in the key: The information content can only be decoded beginning at / by a specific time point.

- Key is dependent on the transmission medium: The information content can only be decoded if the transmission medium has a specific identification.
- Key dependent on the original source: The information content can only be decoded at, for example, the device that recorded it in order to provide protection against misuse when creating backup copies.

Use of cascaded keys:
Cascaded keys can be used to partially encode the information content. For example, this method can be applied to transmit a normal quality in coded form and a poor quality, for example for a pictorial preview, in un-coded form in the same data stream without any consequent redundancy. Such redundancy can, for example, reduce the resolution of a picture. In this context, "resolution" does not mean "picture height x picture width", since this parameter doesn't change when using this method. Rather, a reduction in resolution indicates a deviation in the original image, which can occur during reconstruction because of pixel groups that have not yet been transmitted and/or decoded. The method of cascaded keys works according to the principle of the onion layer. For example, in using the method of prioritized pixel transmission, the pixel group size can be reduced to create a cascaded keying sequence. A pixel group consists of a (reference) pixel that is clearly specified by its positional value, and a number of other pixels. For example, if a pixel group consists of a total of 9 pixels, 5 pixels can be transmitted in un-coded form and 4 pixels can be transmitted in coded for. The outer layer that includes the 5 un-coded pixels contains no coding and would permit the viewing of a video at postage stamp size without a key, for example. At the next layer, one or more of the coded pixels are transmitted. For each further layer, another key is used. The type of layer is agreed upon between sender and receiver prior to the transmission. In this way, whoever has all the keys and can decode all the layers can view the video in the best quality.

In order to reduce disruptions that can arise as a result of, for example, dependencies between the data of the individual layers, a hash value can be transmitted along with the positional value and the values of the pixel groups in this type of coding. This hash value is calculated from the positional value and the values of the pixel groups. If the hash value calculated in the receiver does not agree with the transmitted hash value, these pixel groups are not decoded. This prevents any disruptions from other layers from occurring.

It is possible to combine the different keys and methods.

Of course, the coding method according to the invention is not just applicable to image and video data, but also to all types of digital data that can be subdivided into data blocks, similar to the data blocks of image points.

This invention is explained in more detail below with the help of a simple example.

In Table 1, a portion of a data stream is shown that was prepared according to the prioritized pixel transmission method. The value "Pos x" indicates the respective position

of the pixel group, "Px_n" indicates the individual pixel values of the pixels contained in the pixel group. For example, each pixel group consists of 5 pixels.

Table 1:

PosO	P0_0	P0_1	P0_2	P0_3	P0_4	P0_5	Pos1	P1_0	P1_1	P1_2	P1_3	P1_4	P1_5

Table 2 indicates the coding of just the positional values. Advantage: only a portion of the data stream needs to be coded, which provides a clear increase in performance compared to a complete coding of all data. A reconstruction of the data so coded without knowledge of the key is not possible, or it is only possible with a lot of computing power.

Table 2:

PosO	P0_0	P0_1	P0_2	P0_3	P0_4	P0_5	Pos1	P1_0	P1_1	P1_2	P1_3	P1_4	P1_5

Table 3 indicates the coding of part of the pixel groups. Advantage: The same pixel group provides different qualities of image, audio or video data reconstruction due to differences in coding of the pixel values. In the example illustrated below, the receiver can use the positional value and the pixel values Px_0 through Px_2 without a key. To decode the pixel values Px_3 through Px_5, the correct keys are needed respectively. If the receiver does not have the key(s) for the pixel values Px_3 through Px_5, the application must reconstruct these pixel values from the available values Px_0 through Px_2. However, since the receiver is missing a number of pixel values, the quality of the reconstruction (resolution) is considerably reduced.

Table 3:

PosO	P0_0	P0_1	P0_2	P0_3	P0_4	P0_5	Pos1	P1_0	P1_1	P1_2	P1_3	P1_4	P1_5

In the examples illustrated, coded and un-coded data are transmitted in the same data stream. In order to recognize transmission errors and to recognize whether the decoding was successful, each portion of the pixel group (position value and Px_n) can receive a CRC check in decoded form. If a transmission error occurs, and the CRC check fails, the corresponding pixel value is not used in the reconstruction. The other portion of the pixel group can continue to be used. In this way, the robustness of the transmission process against transmission errors increases at the same time. Instead of a CRC check, hash functions can be used. These offer better backup protection, but require more computing power.